

1 Polydactyly is an inherited condition caused by a dominant allele.

(a) The figure below shows the hand of a man with polydactyly. The man has an extra finger on each hand.

The man's mother also has polydactyly but his father does not.



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(i) The man is **heterozygous** for polydactyly.

Explain how the information given above shows that the man is **heterozygous** for polydactyly.

(3)

(ii) The man marries a woman who does **not** have polydactyly.

What is the probability that their first child will have polydactyly?

(1)

(b) The man has red hair. His sister has brown hair.

Both of their parents have brown hair.

Brown hair is caused by the dominant allele, **B**.

Red hair is caused by a recessive allele, **b**.

Complete the genetic diagram below to show how the man's parents were able to have some children with red hair and some with brown hair.

| | Father | Mother |
|---------------------|----------------|----------------|
| Parental phenotypes | _____ | _____ |
| Parental Genotypes | _____ | _____ |
| Gametes | _____ _____ | _____ _____ |

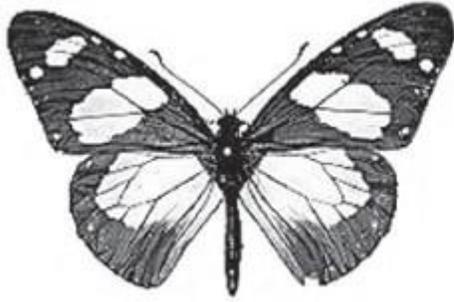
Offspring genotypes: _____

Offspring phenotypes: _____

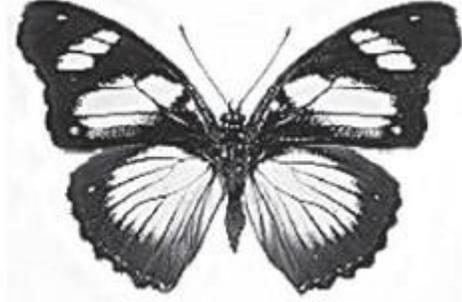
(5)
(Total 9 marks)

2

The drawings show two different species of butterfly.



Amauris



Hypolimnas

- Both species can be eaten by most birds.
- *Amauris* has an unpleasant taste which birds do **not** like, so birds have learned **not** to prey on it.
- *Hypolimnas* does **not** have an unpleasant taste but most birds do **not** prey on it.

(a) Suggest why most birds do **not** prey on *Hypolimnas*.

(2)

(b) Suggest an explanation, in terms of natural selection, for the markings on the wings of *Hypolimnas*.

(3)

(Total 5 marks)

3

Read the information.

Insects can be both useful and harmful to crop plants.
Insects such as bees pollinate the flowers of some crop plants. Pollination is needed for successful sexual reproduction of crop plants.
Some insects eat crops and other insects eat the insects that eat crops.

Corn borers are insects that eat maize plants.
A toxin produced by the bacterium *Bacillus thuringiensis* kills insects.
Scientists grow *Bacillus thuringiensis* in large containers. The toxin is collected from the containers and is sprayed over maize crops to kill corn borers.

A company has developed genetically modified (GM) maize plants. GM maize plants contain a gene from *Bacillus thuringiensis*. This gene changes the GM maize plants so that they produce the toxin.

(a) Describe how scientists can transfer the gene from *Bacillus thuringiensis* to maize plants.

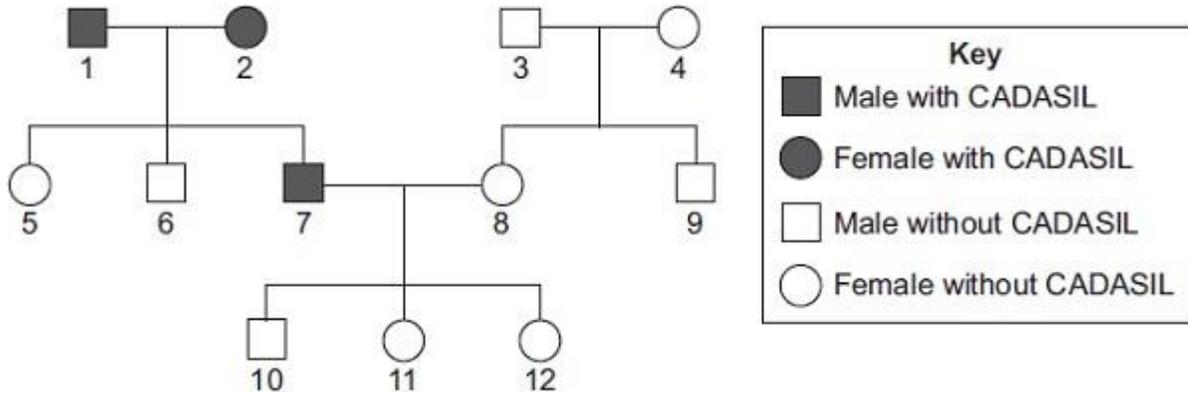
(3)

4

CADASIL is an inherited disorder caused by a dominant allele.

CADASIL leads to weakening of blood vessels in the brain.

The diagram shows the inheritance of CADASIL in one family.



(a) CADASIL is caused by a *dominant allele*.

(i) What is a *dominant allele*?

(1)

(ii) What is the evidence in the diagram that CADASIL is caused by a dominant allele?

(1)

(iii) Person 7 has CADASIL.

Is person 7 homozygous or heterozygous for the CADASIL allele?

Give evidence for your answer from the diagram.

(1)

- (b) Persons **7** and **8** are planning to have another baby.
Use a genetic diagram to find the probability that the new baby will develop into a person with CADASIL.

Use the following symbols to represent alleles.

D = allele for CADASIL

d = allele for not having CADASIL

Probability = _____

(4)

- (c) Scientists are trying to develop a treatment for CADASIL using stem cells.

Specially treated stem cells would be injected into the damaged part of the brain.

- (i) Why do the scientists use stem cells?

(2)

- (ii) Embryonic stem cells can be obtained by removing a few cells from a human embryo. In 2006, scientists in Japan discovered how to change adult skin cells into stem cells. Suggest **one** advantage of using stem cells from adult skin cells.

(1)

(Total 10 marks)

5 Darwin suggested the theory of natural selection.

(a) Explain how natural selection occurs.

(3)

(b) Latitude is a measure of distance from the Earth's equator.

Scientists investigated the effect of latitude on:

- the time taken for new species to evolve
- the number of living species.

The table shows the scientists' results.

| Latitude in degrees North of equator | Time taken for new species to evolve in millions of years | Relative number of living species |
|--------------------------------------|---|-----------------------------------|
| 0 (at the equator) | 3–4 | 100 |
| 25 | 2 | 80 |
| 50 | 1 | 30 |
| 75 (in the Arctic) | 0.5 | 20 |

As latitude increases environmental conditions become more severe.

(i) Describe the patterns shown by the data.

(2)

(ii) Suggest explanations for the patterns you have described in part (b)(i).

(2)

(Total 7 marks)

6

Phenylketonuria (PKU) is an inherited condition. PKU makes people ill.

(a) PKU is caused by a recessive allele.

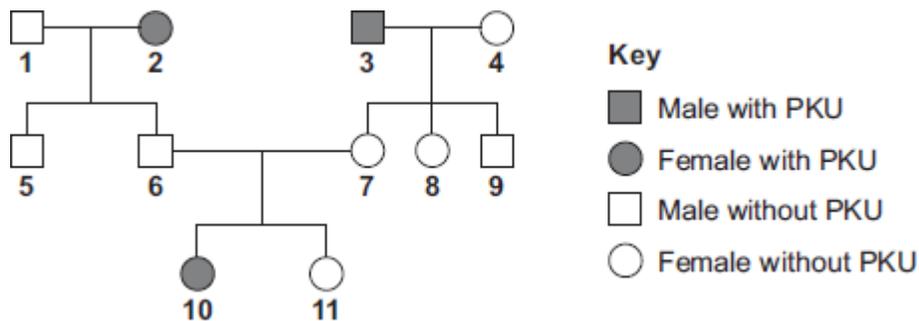
(i) What is an allele?

(1)

(ii) What is meant by recessive?

(1)

(b) The diagram below shows the inheritance of PKU in one family.



(i) Give **one** piece of evidence from the diagram that PKU is caused by a recessive allele.

(1)

(ii) Persons **6** and **7** are planning to have another child. Use a genetic diagram to find the probability that the new child will have PKU.

Use the following symbols in your answer:

N = the dominant allele for **not** having PKU

n = the recessive allele for PKU.

Probability = _____

(4)

(c) Persons **6** and **7** wish to avoid having another child with PKU.

A genetic counsellor advises that they could produce several embryos by IVF treatment.

(i) During IVF treatment, each fertilised egg cell forms an embryo by cell division.

Name this type of cell division.

(1)

(ii) An embryo screening technique could be used to find the genotype of each embryo.

An unaffected embryo could then be placed in person **7**'s uterus.

The screening technique is carried out on a cell from an embryo after just three cell divisions of the fertilised egg.

How many cells will there be in an embryo after the fertilised egg has

divided three times?

(1)

(iii) During embryo screening, a technician tests the genetic material of the embryo to find out which alleles are present.

The genetic material is made up of large molecules of a chemical substance.

Name this chemical substance.

(1)

(d) Some people have ethical objections to embryo screening.

(i) Give **one** ethical objection to embryo screening.

(1)

(ii) Give **one** reason in favour of embryo screening.

(1)

(Total 12 marks)

- 7 (a) Evidence about extinct species of animals and plants comes from fossils.

Below is a photograph of a fossil of a bird-like animal called *Archaeopteryx*. *Archaeopteryx* lived about 150 million years ago.



© Wlad74/iStock/Thinkstock

- (i) Suggest how the fossil of *Archaeopteryx* was formed.

(2)

- (ii) Scientists have found other fossils of the ancestors of modern birds, but the fossil record is very incomplete.

Suggest **two** reasons why there are gaps in the fossil record.

1. _____

2. _____

(2)

Mark schemes

- 1** (a) (i) man has (inherited) polydactyly (PD) allele (from mother) 1
- man has (inherited) other / normal / recessive allele from father 1
- because father does not have PD allele **or** if father had it father would have had PD **or** father only has normal allele **or** father is homozygous recessive 1
- allow gene for allele*
- (ii) 0.5 / $\frac{1}{2}$ / 1 in 2 / 1:1 / 50% 1
- do not allow 1:2 or 50/50*
- allow 50:50*
- (b) parental phenotypes: both brown 1
- parental genotypes: both **Bb** 1
- gametes: **B b** and **B b** 1
- allow only on gametes answer line*
- allow ecf from genotypes*
- offspring genotypes: **BB (2)Bb bb** 1
- allow ecf from gametes*
- offspring phenotypes correctly assigned to genotypes:
BB & Bb = brown **bb** = red 1
- do not penalise confusion of 'phenotypes' & 'genotypes' here*
- [9]**
- 2** (a) wing pattern similar to *Amauris* 1
- allow looks similar to Amauris*
- birds assume it will have an unpleasant taste 1
- (b) mutation / variation produced wing pattern similar to *Amauris* 1
- do not accept breeds with Amauris*
- do not accept idea of intentional adaptation*
- these butterflies not eaten (by birds) 1

these butterflies breed **or** their genes are passed to the next generation

1

[5]

3

(a) any **three** from:

- (gene) cut out
- (gene / cut out) from (bacterial) chromosome / DNA
accept (gene / cut out) from (bacterial) plasmid
- ref to enzymes (at any point)
- (gene spliced) into maize chromosome / DNA
- (gene added) at an early stage of development

3

(b) any **four** from:

- justification based on comparison of the relative merits of at least one advantage and one disadvantage
max 3 marks if only advantages or disadvantages given

Advantages:

- less effort for farmer **or** less likely to harm farmer
ignore ref to cost
- (pesticide) always there **or** doesn't wash away
allow examples eg no need to spray
- less insects to eat crop / maize **or** carry disease
allow pesticide doesn't contaminate water courses
- so greater crop production / yield

Disadvantages:

- (toxin) kills other insects
ignore ref to cost
- so (some) crops don't get pollinated / (sexually) reproduce
allow maize not pollinated
- possible harm when eaten by humans / animals
allow may have unpleasant taste
- damage to food chains
allow reduced biodiversity
- gene may spread to other species

4

[7]

4

(a) (i) allele expressed even when other allele present **or** expressed if just one copy of allele is present **or** expressed if heterozygous
if present other allele not expressed

1

(ii) 2 affected parents have unaffected child **or** 1 and 2 → **5 / 6**

or if recessive all of **1** and **2**'s children would have CADASIL

1

(iii) heterozygous – has unaffected children **or** because if homozygous all children would have CADASIL

1

(b) genetic diagram including:

accept alternative symbols, if defined

1

correct gametes:

D and **d**
and d (and **d**)

ignore 7 / 8 or male / female

1

derivation of offspring genotypes:

Dd Dd dd dd

*allow just **Dd dd** if ½-diagram
allow ecf if correct for student's gametes*

1

identification **of Dd** as CADASIL

or dd as unaffected

allow ecf if correct for student's gametes

1

correct probability: 0.5 / ½ / 1 in 2 / 50% / 1 : 1

1

(c) (i) stem cells can differentiate **or** are undifferentiated / unspecialised

1

can form blood vessel cells / brain cells

or

stem cells can divide

1

- (ii) ethical argument - eg no risk of damage to embryo or adult can give consent for removal of cells **or** adult can re-grow skin

more ethical qualified

ignore religion unqualified

or

if from a relative then less chance of rejection **or** if from self then no chance of rejection

or

skin cells more accessible

1

[10]

5

- (a) variation (between organisms within species)

allow described example

*allow mutation – but **not** if caused by change in conditions*

1

those most suited / fittest survive

1

genes / alleles passed on (to offspring / next generation)

allow mutation passed on

1

- (b) (i) any **two** from:

allow converse

- increase in latitude reduces number of (living) species
ignore references to severity of conditions
- increase in latitude reduces time for evolution (of new species)
- the less the time to evolve the fewer the number of (living) species

2

- (ii) any **two** from:

*do **not** accept intention or need to evolve*

- (increase in latitude reduces number of (living) species because) less food / habitats / more competition at high latitude
allow only extremophiles / well-adapted species can survive
- (increase in latitude reduces time for evolution (of new species) because) severe conditions act more quickly / to a greater extent on the weakest
- (the less the time to evolve the fewer the number of (living) species because) species that evolve slowly don't survive

2

[7]

- 6** (a) (i) one form of a / one gene
do **not** allow 'a type of gene'
allow a mutation of a gene 1
- (ii) not expressed if dominant / other allele is present / if heterozygous
or
only expressed if dominant allele not present / or no other allele present
allow need two copies to be expressed / not expressed if only one copy / only expressed if homozygous 1
- (b) (i) two parents without PKU produce a child with PKU / **6** and **7** → **10**
allow 'it skips a generation' 1
- (ii) genetic diagram including:
accept alternative symbols if defined
- Parental gametes:
6: N and n
and 7: N and n 1
- derivation of offspring genotypes:
NN Nn Nn nn
allow genotypes correctly derived from student's parental gametes 1
- identification: **NN** and **Nn** as non-PKU
OR nn as PKU
allow correct identification of student's offspring genotypes 1
- correct probability only: 0.25 / ¼ / 1 in 4 / 25% / 1 : 3
do **not** allow 3 : 1 / 1 : 4
do **not** allow if extra incorrect probabilities given 1
- (c) (i) mitosis
correct spelling only 1
- (ii) 8 1

- (iii) DNA
allow deoxyribonucleic acid
*do **not** allow RNA / ribonucleic acid*

1

- (d) (i) may lead to damage to embryo / may destroy embryos / embryo cannot give consent

allow avoid abortion
allow emotive terms – eg murder religious argument must be qualified
allow ref to miscarriage
allow idea of avoiding prejudice against disabled people
allow idea of not producing designer babies

1

- (ii) any **one** from:

- prevent having child with the disorder / prevent future suffering / reduce incidence of the disease
ignore ref to having a healthy child
ignore ref to selection of gender
- embryo cells could be used in stem cell treatment
allow ref to long term cost of treating a child (with a disorder)
allow ref to time for parents to become prepared

1

[12]

7

- (a) (i) any **two** from:

- (dead) animal buried in sediment
allow imprint in mud
- hard parts / bones do not decay **or** soft parts do decay
allow (one of) the conditions for decay is missing – accept example, eg oxygen / water / correct temperature / bacteria
- mineralisation (of hard parts / bones)
allow replacement by other materials

2

- (ii) any **two** from:

- conditions not right for fossilisation
ignore references to soft-bodied
- geological activity has destroyed fossils / has destroyed evidence
allow a named / described example – eg vulcanism / earth movements / erosion
- fossils not yet found
allow description of why not yet found

2

(b) any **four** from:

- separation / isolation (of different populations)
- different environmental conditions (between locations)
- mutation(s) occur **or** genetic variation (within each population)
- better adapted survive **or** natural selection occurs
 - allow 'survival of the fittest'*
 - ignore animals adapt to their environment*
 - ignore reference to stronger survive*
- favourable alleles passed on (in each population)
 - allow genes for alleles*
- eventually different populations unable to breed successfully with each other
 - allow unable to produce fertile offspring*

4

[8]